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EFFECTS OF SOIL CONSERVATION ON SEDIMENTATION IN LAKE ISSAQUEENA

PICKENS COUNTY, SOUTH CAROLINA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
H. H. Bennett, Chief

SOUTHEASTERN REGION
T. S. Buie, Regional Director

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UNITED STATES DEPARTMENT OF AGRICULTURE
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PICKENS COUNTY, SOUTH CAROLINA

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Spartanburg, South Carolina

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ABSTRACT

Lake Issaqueena is a recreational lake located seven miles northwest of Clemson in Pickens County, South Carolina. The 14-square-mile watershed is situated in a steep, badly eroded section of the upper Piedmont Plateau just east of the Blue Ridge Mountains. The average annual loss of storage capacity for the 2.9 year period 1938 to 1941 was 1.69 percent, whereas the average annual rate for the 8.5 year period 1941 to 1949 was only .78 percent. This reduction of 53 percent occurred despite the fact that the average annual rainfall and excess of inflow over mean discharge into the reservoir were higher during the second period than during the first period of record.

About half of the sediment was deposited in the upper fourth of the reservoir length, and more than half was deposited in the top 30 percent of the reservoir depth.

Sheet erosion on cultivated fields has been the principal source of sediment. Gullies, road banks, and stream banks were other significant sediment sources. Between 1941 and 1949 the proportion of the watershed classed as having moderate to good erosion protection increased from 53 to 73 percent. The adoption of soil conservation measures and better land use practices are considered to have been primarily responsible for the reduction in sedimentation. Most of the improvement took place on cultivated lands. The most important single conservation practice was rotation strip cropping on 1,412 acres. It is estimated that better land use and conservation practices reduced the amount of gross soil movement by 36.6 percent between 1941 and 1949. During the same period, watershed improvement and vegetative growth above the reservoir reduced sediment inflow by 53 percent. Thus a smaller portion of the total volume of soil eroded was getting into the reservoir.

Although the average rate of sediment production was reduced from 2.22 to 1.03 acre-feet per year per square mile of drainage area, it was still about double the average rate for the Piedmont area. Land use conditions can be and should be further improved, particularly on the cultivated lands. Additional treatment of gullies, roads, and stream banks is needed.

* * * * * * * * * *

INTRODUCTION

This report gives the results of a study of the effects of soil conservation on sedimentation in Lake Issaqueena, near Clemson, Pickens County, South Carolina. The land use and erosion conditions in the watershed area of 14 square miles (net sediment producing area 8,868 acres) are described. Changes in land use and the application of conservation practices since 1941 are shown to have had a marked effect in reducing the rate of sedimentation in the reservoir.

Lake Issaqueena is a recreational development built in 1938 as part of a Land Utilization Project and later leased to Clemson College. The watershed draining into the lake was particularly well suited for this study because of the wealth of detailed information already available, its relatively small size, and the unusually severe erosion problems.

This study was made by the Water Conservation Division, Southeastern Region of the Soil Conservation Service, with the cooperation of Clemson College.[1]

PREVIOUS STUDIES

The Sedimentation Section, Office of Research, Soil Conservation Service, made a detailed sedimentation survey of Lake Issaqueena during April 1941.[2] The Regional Farm Planning and Management Division made a planning study of Six Mile Creek Watershed in 1941.[3] The Regional Soil Conservation Surveys Division made a detailed conservation survey of the watershed in 1941.

Material from these studies were used throughout this report.

THE RESERVOIR AND WATERSHED

Location

Lake Issaqueena is located in Pickens County, northwestern South Carolina. The reservoir is about seven miles by road northwest of Clemson, and one-half mile east of State Highway No. 39, where it crosses the Keowee River at Lawrence Bridge (fig. 1). The dam impounds Six Mile Creek one-third of a mile above its confluence with the Keowee River.

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[1] *Field work done by John J. Noll, John W. Roehl, and Jackson Bennett, Geologists; John R. Allen and C. C. Vaughan, Civil Engineers; and Marion Etheredge, Engineering Aid, Soil Conservation Service.*

[2] *Zwerner, G. A., Johnson, J. W., and Flaxman, E. M., Advance Report on the Sedimentation Survey and Suspended-Matter Observations in Lake Issaqueena, Clemson, South Carolina, 1940-1941, U.S.D.A., S.C.S., Sediment Section, Office of Research, SCS-SS-37, November 1942.*

[3] *Brown, Hugh A., Report of a Planning Study on Six Mile Creek Watershed above Clemson College, South Carolina. U.S.D.A., S.C.S., Southeastern Region, Farm Planning and Management Division, 1941. Unpublished Report.*

Dam and Lake

The dam is a cyclopean-concrete, gravity-type structure, 325 feet long with the top 51.5 feet above bedrock. The spillway section, approximately in the middle of the structure, is 100 feet long, has a freeboard of 7 feet and a maximum discharge capacity of 4,668 cubic feet per second. There are two manually operated outlets 34 feet below spillway crest. Storage began in June 1938. The total cost of construction was $124,438.53, but at present day prices (1950) would be about $250,000.

The reservoir basin is long and narrow with a relatively steep shoreline (fig.22). The length of the lake is now about 6,000 feet. Width varies from about 300 to 1,200 feet. The original surface area was 117 acres, but delta deposits at the upper end of the lake have reduced the surface area to 106 acres. Sediment has reduced the original storage capacity of 1,836 acre-feet to 1,626 acre-feet.

General Description of Watershed

The watershed is about 7.9 miles in length, 1.7 miles wide, and contains 8,868 acres, excluding the lake area.

Topography and Slope

The watershed is in the upper Piedmont Plateau and has an average elevation of a little under 1,000 feet (fig.1). It is a highly dissected area with narrow, steep-sided stream valleys. Topography varies from rolling, on the relatively wide, highly cultivated ridge tops in the upper portions of the area, to rough and broken wooded slopes in the lower watershed. Stream gradients become progressively steeper downstream and are controlled by bedrock throughout most of their length. Land slope classes are shown in table 1.

Table 1 - Distribution of land slope classes

SLOPE CLASS	ACRES	PERCENT
A slopes, 0-2 percent	307	3.5
B slopes, 2-7 percent	1,137	12.8
BB slopes, 7-10 percent	1,971	22.2
C slopes, 10-14 percent	1,566	17.6
D slopes, 14-25 percent	2,542	28.7
E slopes, 25 percent and over	1,345	15.2
Total	8,868[1]	100.0

[1] *Net sediment-contributing area in 1949*

Geology and Soils

The residual soils are developed from underlying granites, gneisses, schists, and dark colored basic rocks. The predominant soils are well to excessively drained, acid, low in organic matter, highly erodible, with a light brown, gravelly sandy loam surface soil and a red clay subsoil. From one-half to three-fourths of the normal soil profile consists of particles of sand and fine gravel. This large supply of coarse grained material accounts in part, at least, for the large proportion of delta deposits in the reservoir.

Agricultural History

The area which is now Pickens County was originally part of the hunting grounds of the Cherokee Indians. The original vegetation was mainly deciduous forest with some shortleaf and Virginia pine mixed with the hardwoods on the uplands. The forests were relatively free of heavy undergrowth. Canebrakes bordered the streams. The only cultivated lands were small patches of corn planted by the Indians along stream bottoms. When the territory was ceded to South Carolina in 1777 there were few, if any, white settlers in the area and settlement was slow for a number of years after this date[1].

The earliest settlers farmed only the bottom lands. Gradually, as the need for additional land arose, the uplands were cleared and put into cultivation. The principal crops grown in the early days were corn, oats rye, and wheat. Later, indigo, tobacco, and flax were grown. Cotton was introduced about 1802, but did not become an important crop until after 1860.

In the early days, land was cheap and plentiful, and farmers made little or no attempt to maintain soil fertility. Worn out land was abandoned and new fields were cleared and put into cultivation. The use of soil-building crops, systematic crop rotations, and fertilization did not come into general use until comparatively recent times.[2]

Cotton became increasingly important after 1860; and between 1909 and 1930 succeeded corn as the principal crop. The years 1860 to 1930 represent the period of most intensive agricultural use and the most severe and destructive soil erosion. Since 1930 the trend has been toward diversification of crops, improved crop rotations and increased use of commercial fertilizers. The cotton acreage has decreased; the acreage of wheat, oats, and soil building crops such as cowpeas, soybeans, and especially lespedeza has increased.

Land Ownership

About 73 percent of the watershed area is privately-owned and 27 percent is government-owned (Fig. 1). Most of the 2,421 acres of government-owned land was acquired under Title III of the Bankhead-Jones Law, and was originally a part of Land Utilization Project LU-SC-3. In 1939 Clemson College obtained this land under the terms of a 95-year cooperative and license agreement. Later an additional area purchased by the the Department of the Army was added to the project.

---

[1] *Ramsey, David, History of South Carolina from its First Settlement in 1670 to 1808. 2V, illus., Charleston, 1858.*

[2] *Shearin, A.E., Simmons, C.S., Lesh, F.R., and Wonser, C.H., Soil Survey, Pickens County, South Carolina, U.S.D.A., Bureau of Plant Industry, July 1943.*

The farms are generally small, averaging about 42 acres. In 1941, 69 percent of the farms were owner-operated and 31 percent were operated by tenants. The quality of farm management is generally good and crop yields are above the average for the state.

Sheet and Gully Erosion

The watershed is situated in one of the more seriously eroded portions of the Piedmont Plateau. Severe to very severe sheet erosion has occurred on about three-fourths of the total area. Observations in the field indicate that in this watershed sheet erosion on cultivated lands is, by far, the greatest source of sediment.

Occasional shallow gullies and galled spots occur on most of the upland area. A few small areas have been destroyed by one or more large gullies, although there are less than twelve deep, caving-type gullies in the entire watershed. The distribution of erosion classes is shown in table 2 below.

Table 2 - Distribution of erosion classes

EROSION CLASS	ACRES	PERCENT
No apparent erosion	411	4.6
Slight erosion	720	8.1
Moderate erosion	1,250	14.1
Severe erosion	3,626	40.9
Very severe erosion	2,861	32.2
Total	8,868[1]	100.0

[1] *Net sediment-contributing area in 1949.*

Road-bank Erosion

Erosion on raw, exposed road banks is an important source of sediment. Roadside ditches concentrate runoff and transport a relatively large portion of the total material eroded from the banks and from adjacent land areas directly into stream channels.

Streambank Erosion

Unstable, caving stream banks above the reservoir are another, although less important, source of sediment. Most of the stream bank erosion occurs in the narrow, headwater valleys where protective vegetative growth on the streambanks has been destroyed or suppressed by overgrazing or cultivation.

HYDROLOGY

Climate

This section has comparatively mild winters and hot summers. The average January temperature is 41°. The average July temperature is 76°. Snow and freezing temperatures are seldom important contributing

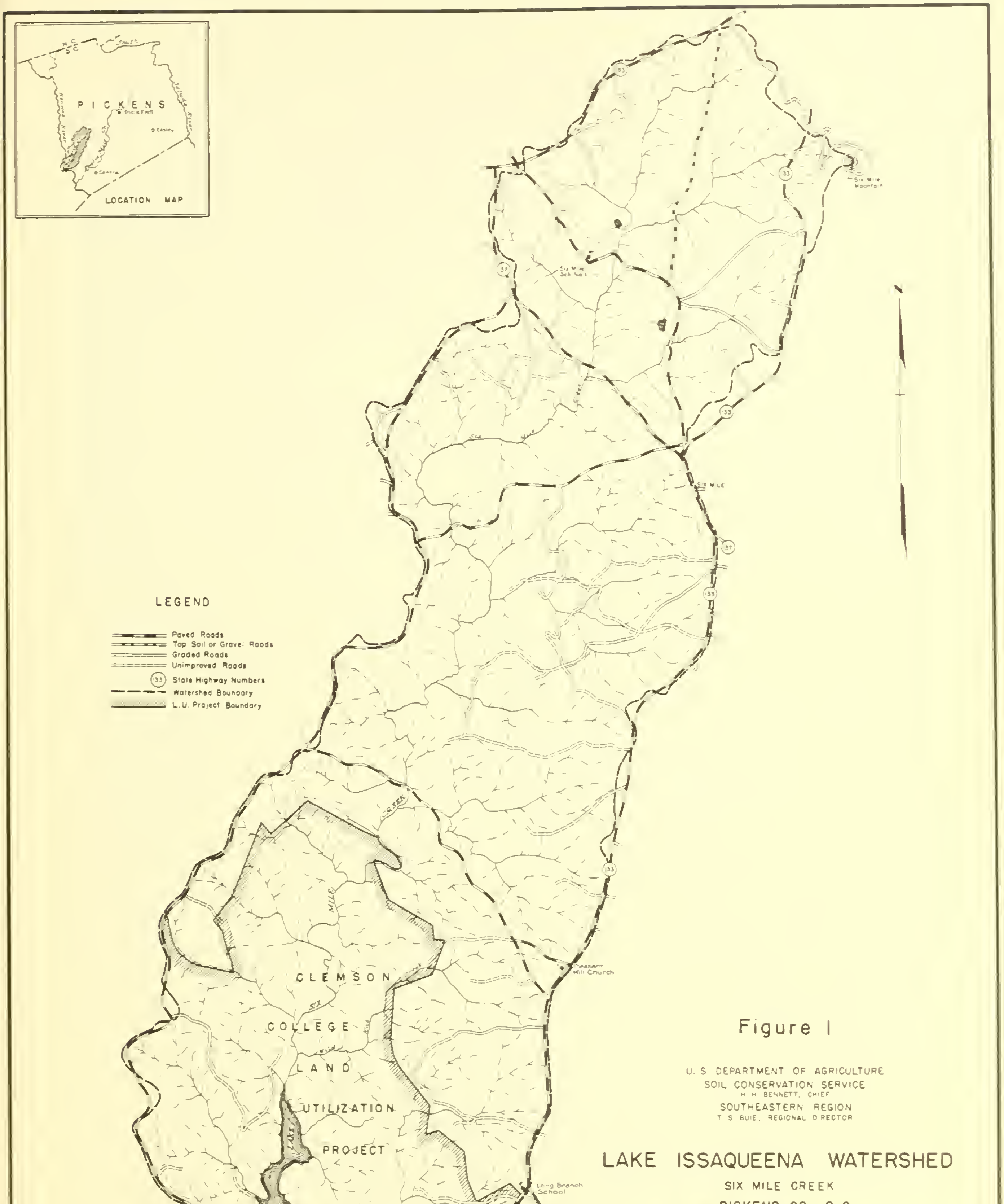

Figure I

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LAKE ISSAQUEENA WATERSHED
SIX MILE CREEK
PICKENS CO., S. C.

APPROX 8974 ACRES

MAY, 1950

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factors to erosion losses and runoff characteristics. The mean yearly temperature is 60.9°. The frost-free season is slightly more than 200 days. Tha average date of the last killing frost in the spring is April 10. October 30 is the average date of the first killing frost in the fall.

September, October, and November are the driest months; otherwise rainfall is relatively evenly distributed throughout the year. Average annual precipitation is 56 inches. Annual rainfall for the period 1941 through 1948 was greater than that occurring during the period 1938 through 1941. Intense storms causing high sediment production may occur at any time during the year but are most frequent during July and August, although the largest number of storms occur from January through April.

Runoff

Water stage recorders were not in operation in the watershed for entire period of storage. Stream flow records were obtained, however, from an automatic stage recorder located on Six Mile Creek near the upper end of the lake for the period December 20,1940 to February 16,1942. The average discharge during this period was about 20 cubic feet per second.

In order to compare stream flow for the two periods of reservoir sedimentation record, an average flow duration curve was prepared for each period from discharge records of three gaged drainage areas nearby. The gaged areas, although differing in size from the Lake Issaqueena watershed, are generally comparable to it in soil, slope, and cover conditions. The average curves, shown in figure 2, indicate a greater runoff during the second period except for the low frequency flows. These curves show that the mean discharge for the period 1938 through 1949 was equalled or exceeded 15.5 percent of the time during the first storage period (1938-41) and approximately 32 percent of the time during the second storage period (1941-49). An extremely heavy storm occurring in August 1940 resulted in unusually high runoff, a magnitude of runoff that was not equalled at any time during the second storage period.

SEDIMENTATION

Method of Survey

A sedimentation resurvey of Lake Issaqueena was made during October 1949. The original plane-table sheets prepared during the 1941 survey were used as base maps for the 1949 survey. The 20 ranges previously established and marked at each end with bronze tablets set in concrete were relocated and sounded with a 5-pound aluminum sounding weight. All of the original range-end markers were found with the exception of R6Lt and R18Rt. Marker R18Rt had been destroyed by a direct bomb hit, as one promontory on the lake shore had been used as a practice bombing target during World War II. Because numerous unexploded practice bombs in the lake bed made direct measurement of sediment thickness with the steel sediment measuring spud somewhat hazardous, all ranges were sounded. Soundings were made as close as possible to the original points of measurements by the use of a plane-table intersection. Sediment thickness was determined by a direct comparison of range profiles.

The storage capacity and sediment volume were calculated for cumulative five-foot increments of reservoir depth by the general formula described below:

$$V = \frac{A'}{3}\left(\frac{E_1 + E_2}{W_1 + W_2}\right) + \frac{A}{3}\left(\frac{E_1}{W_1} + \frac{E_2}{W_2}\right) + \frac{h_3E_3 + h_4E_4 + \ldots\ldots}{130680}$$ [1]

Where V = Original capacity or sediment volume in acre-feet.

A' = The quadrilateral area, i.e., the area in acres of the quadrilateral formed by connecting the points of range intersection with crest contour between the two principal or most nearly parallel ranges.

A = The lake area of the segment in acres.

E = The cross-sectional area, in square feet, of original capacity or sediment volume cut by the bounding range.

W = Width (length of bounding range) at crest elevation, in feet.

h = The perpendicular distance from the range on a tributary to the junction of the tributary with the main stream, or if this junction is outside the segment, to the point where the thalweg of the tributary intersects the downstream range.

The subscripts of E, W, and h identify these quantities with the respective ranges of the segment.

The original capacity and sediment volume for the segment next to the dam was computed by the formula

$$V = A\left(\frac{E}{W}\right)$$

In the 1941 sedimentation survey of Lake Issaqueena, the storage capacity and the volume of sediment were determined by the range method of survey for the area covered by bottom-set beds, and by the contour method for delta areas at the head of the lake and one main arm.

In the 1949 survey the storage capacity and sediment volumes for the entire lake were determined by use of the range formula, but delta segments thus determined were adjusted to the comparable volumes established during the 1941 survey by use of the contour method.

Fourteen samples of undisturbed lake sediment were collected at various points with a check valve sampler. Twelve of the twenty samples of sediment obtained in 1941 were used in conjunction with the abovementioned fourteen samples to arrive at a weighted, average specific weight of the material deposited in the lake[2].

Rates of Silting

The annual rate of sediment production from the watershed, as indicated by the measured volume of below-crest deposits in the reservoir, has declined from 2.22 acre-feet per square mile of drainage area during the first period of record 1938-41 to 1.03 acre-feet per square mile of drainage area during the second period of record 1941-49. This is a decline of approximately 53 percent. These sediment production rates as calculated, however, are the minimum for the respective periods as above-crest deposits and wastage over the dam are not included.

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[1] *Eakin, Henry M., revised by Brown, Carl B., Silting of Reservoirs, Technical Bulletin No. 524, U.S.D.A., Washington, D.C., July 1936, August 1939.*

[2] *Specific-weight determinations of sediment samples were made by Soil Conservation Service Research Station, Clemson, S. C.*

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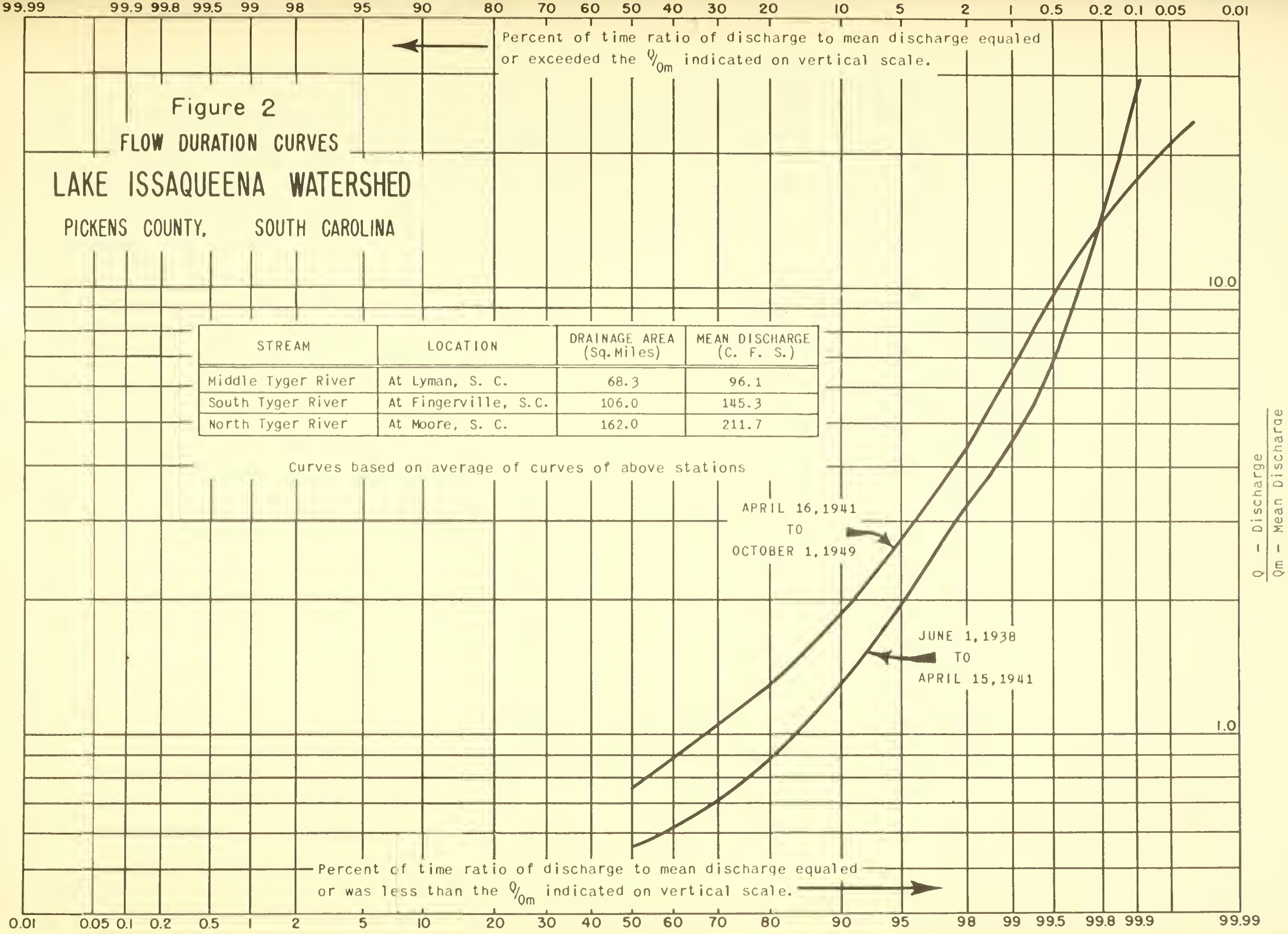

Figure 2

FLOW DURATION CURVES

LAKE ISSAQUEENA WATERSHED

PICKENS COUNTY, SOUTH CAROLINA

STREAM	LOCATION	DRAINAGE AREA (Sq. Miles)	MEAN DISCHARGE (C. F. S.)
Middle Tyger River	At Lyman, S. C.	68.3	96.1
South Tyger River	At Fingerville, S.C.	106.0	145.3
North Tyger River	At Moore, S. C.	162.0	211.7

Curves based on average of curves of above stations

The annual rates of storage capacity loss for the same periods are 1.67 percent and 0.78 percent, respectively, indicating a similar reduction of 53 percent. The average loss to the date of the 1949 survey was 1.01 percent. This reduction of more than 50 percent was accomplished even though the runoff for the second period (1941-49) was greater than that experienced during the period prior to the first survey (Fig.2).

Character of Sediment

The lake was sounded rather than spudded during the 1949 survey on the assumption that the general characteristics of the sediment had not materially changed between the dates of the two surveys. The delta area had been extended during this period but the bottom-set deposits in the lower reaches of the lake remained about the same as to color, texture and volume-weight. The colors of the bottom-set deposits range from light yellow to chocolate brown. An attempt was made during the 1949 survey to secure samples of the sediment in the downstream segments, but the lack of compaction and extreme fluffiness of the material prevented the gathering of an adequate sample for analysis. The sands constituting the delta areas were generally light in color and in the ponded channel areas were quite clean of silt and clay. The changes in specific weight during the time that elapsed between the two surveys, shown in table 3, indicate the gradual extension downstream of the heavier materials forming the delta deposits.

Table 3 - Specific weight of sediment by segments

SEGMENT	AVERAGE WEIGHT OF DRY SOLIDS PER CUBIC FOOT OF DEPOSIT	
	1941 (POUNDS)	1949 (POUNDS)
0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 17, 18,	35	35
10,	38	38
11	39	39
12, 13	40	52
14	41	52
19	48.5	52
15	48.5	72
16, 20	70	72

The weighted average specific weight of the sediment increased from 49.8 pounds per cubic foot in 1941 to 50.9 pounds per cubic foot in 1949.

Distribution of Sediment

In 1949, as in 1941, the sediment was sharply divided into delta and bottom-set deposits. The delta deposits, which were measured in segments 14, 15, 16, 19, and 20, consist of fairly well sorted sands. Above-crest deposits, varying in thickness from several inches to about two feet above spillway crest, occur in these segments (fig.3). The lake area had been reduced 11 acres since storage began and 8 acres since the time of the 1941 survey (fig. 22).

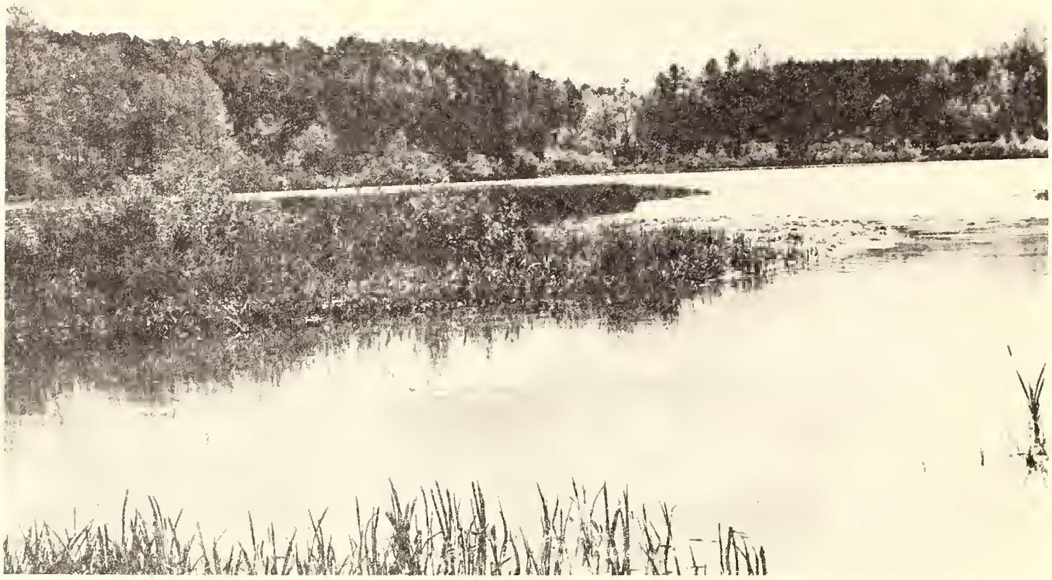

Figure 3 - Deltas in Lake Issaqueena. Range 15 cuts across center of picture[1].

Elevation-capacity curves for Lake Issaqueena in figure 4 show the loss of capacity from the date storage began to the time of the 1941 survey and the continuing loss to the 1949 survey. The subsequent curves have retained practically the same form as the original but have lifted rather uniformly in elevation, the lowest areas of storage being completely filled. This is confirmed by figure 5 which shows the proportional reduction in storage capacity at different elevations.

The reservoir profiles at the time storage began and at the time of the two surveys are shown in figure 6. These profiles not only indicate the shortening of the lake length but also show the deposition of a large part of the sediment in the upper levels. A further indication of this deposition in the upper levels and in the portions of the pool farthest from the dam is shown in figure 7 where percent of total sediment is plotted against distance upstream from the dam. Fifty percent of the sediment is in the upper fourth of the reservoir length.

The excessive deposition in the lower segment of the reservoir, considered on the first survey as resulting from density currents, has decreased. This is shown by the leveling off of the longitudinal profile of the reservoir in the lower reaches.

Figure 8 shows the distribution of sediment as related to lake elevation. In this chart the percent of total sediment is plotted against

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[1] *All photographs used in this report were taken in Lake Issaqueena Watershed.*

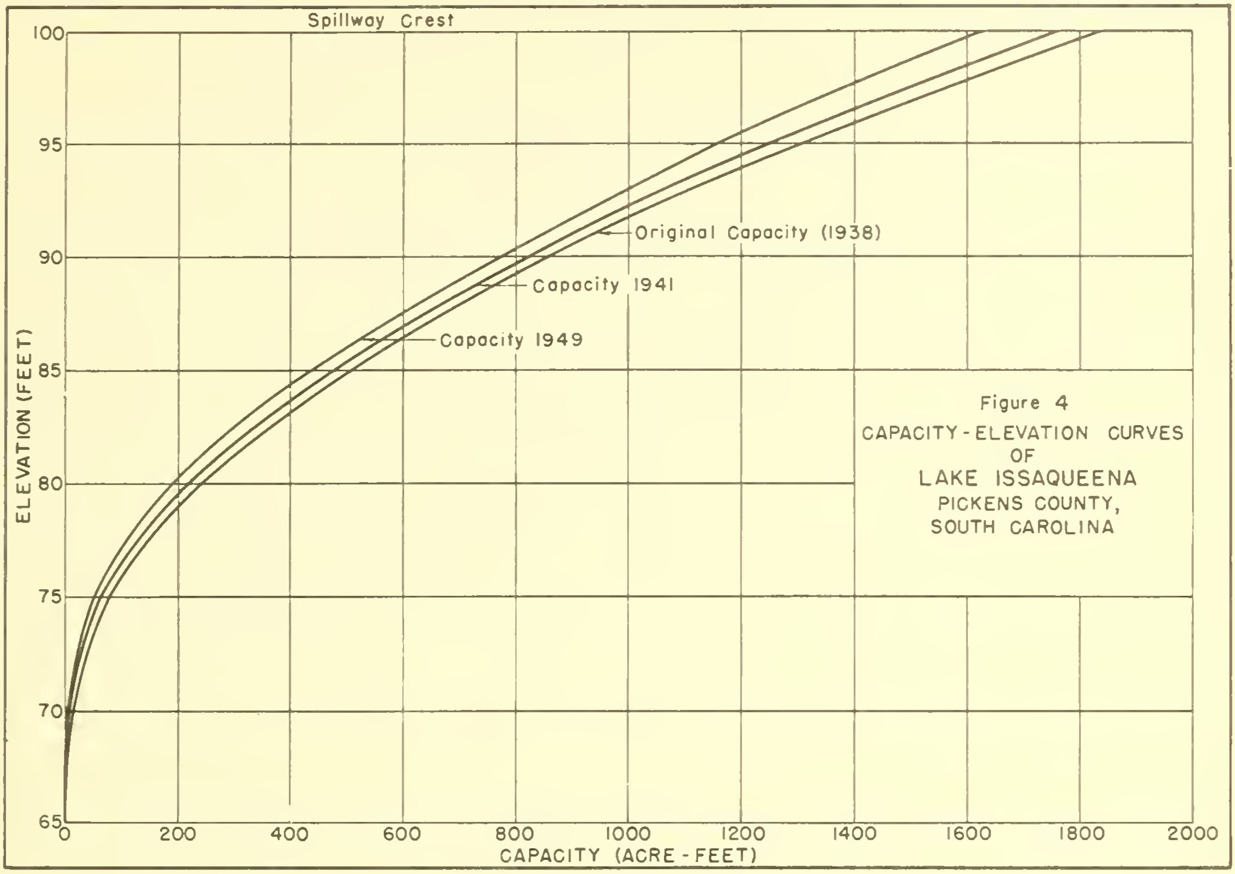

Figure 4
CAPACITY - ELEVATION CURVES
OF
LAKE ISSAQUEENA
PICKENS COUNTY,
SOUTH CAROLINA

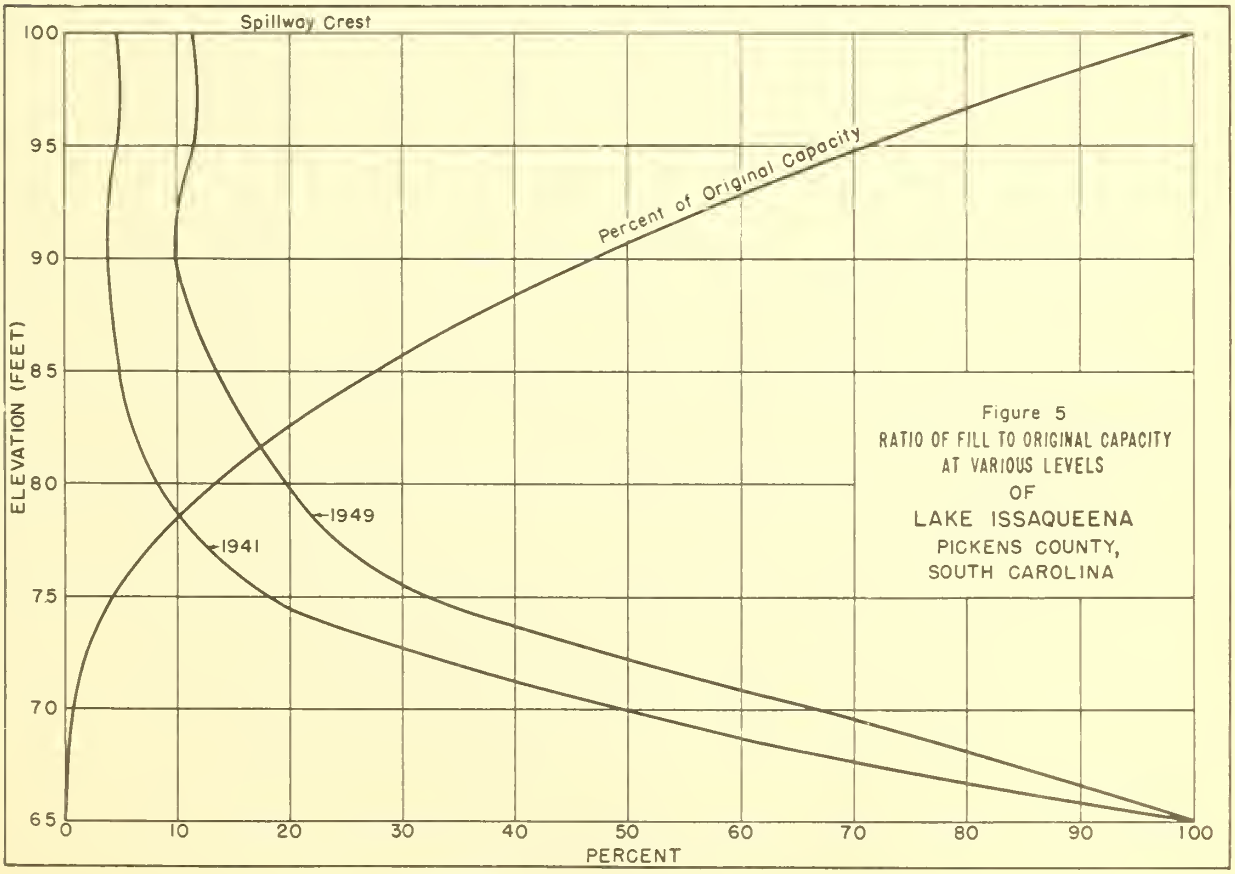

Figure 5
RATIO OF FILL TO ORIGINAL CAPACITY
AT VARIOUS LEVELS
OF
LAKE ISSAQUEENA
PICKENS COUNTY,
SOUTH CAROLINA

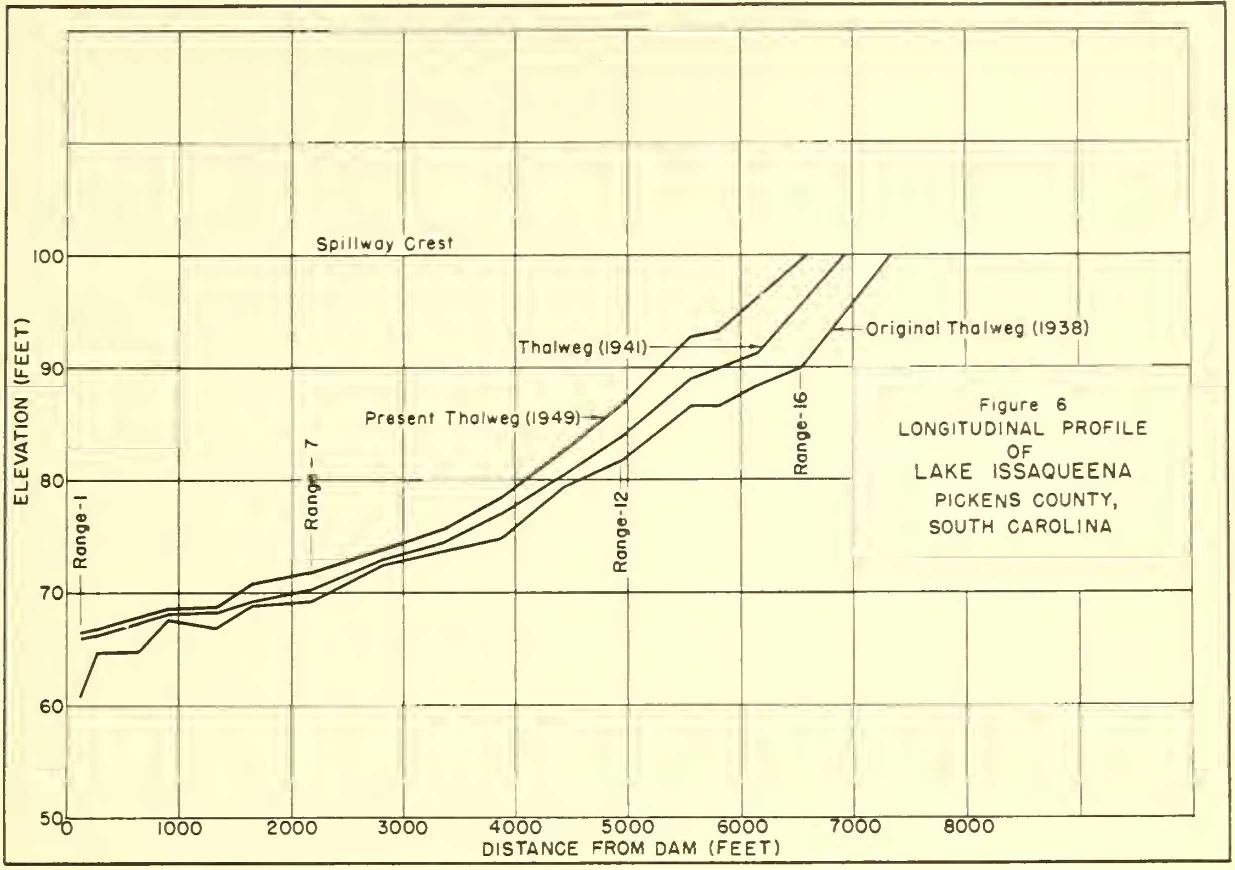

Figure 6
LONGITUDINAL PROFILE
OF
LAKE ISSAQUEENA
PICKENS COUNTY,
SOUTH CAROLINA

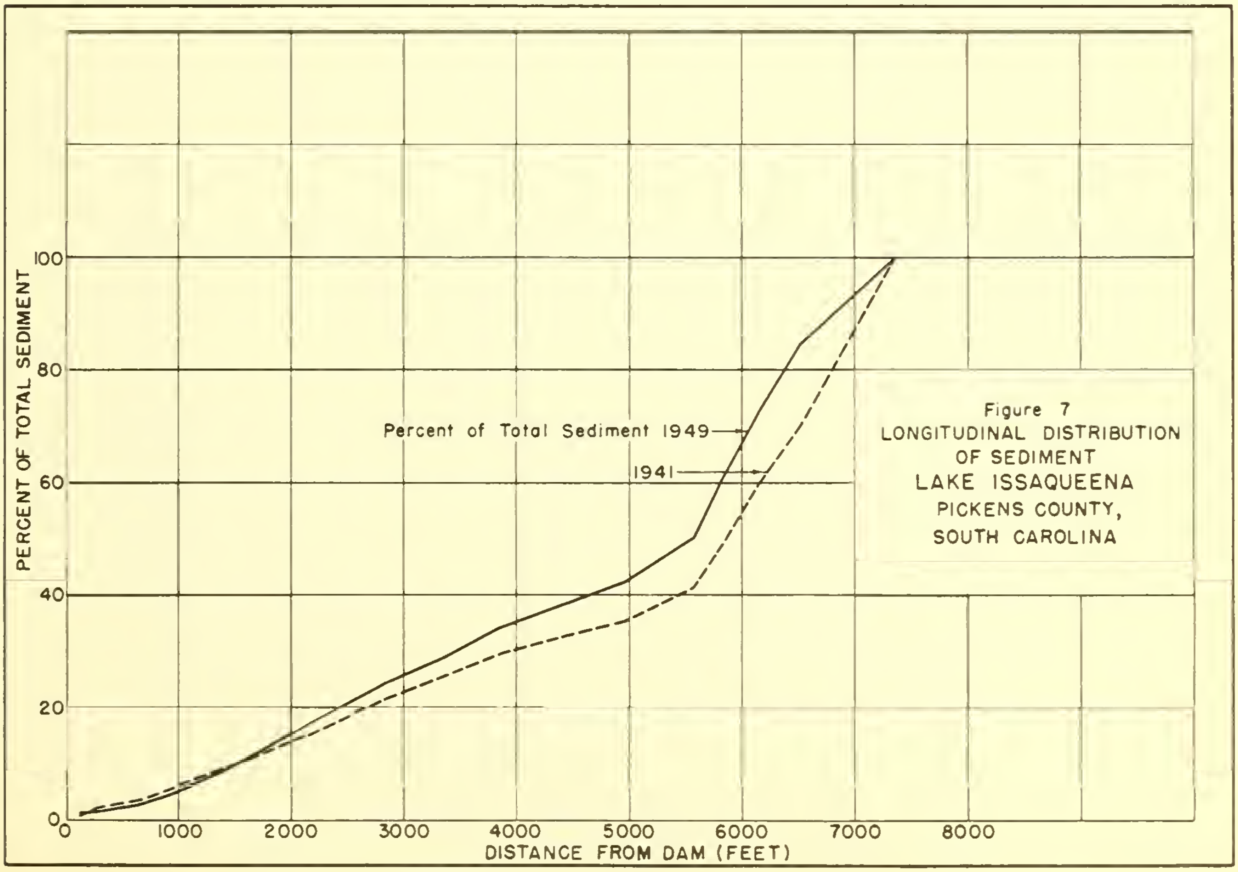

Figure 7
LONGITUDINAL DISTRIBUTION
OF SEDIMENT
LAKE ISSAQUEENA
PICKENS COUNTY,
SOUTH CAROLINA

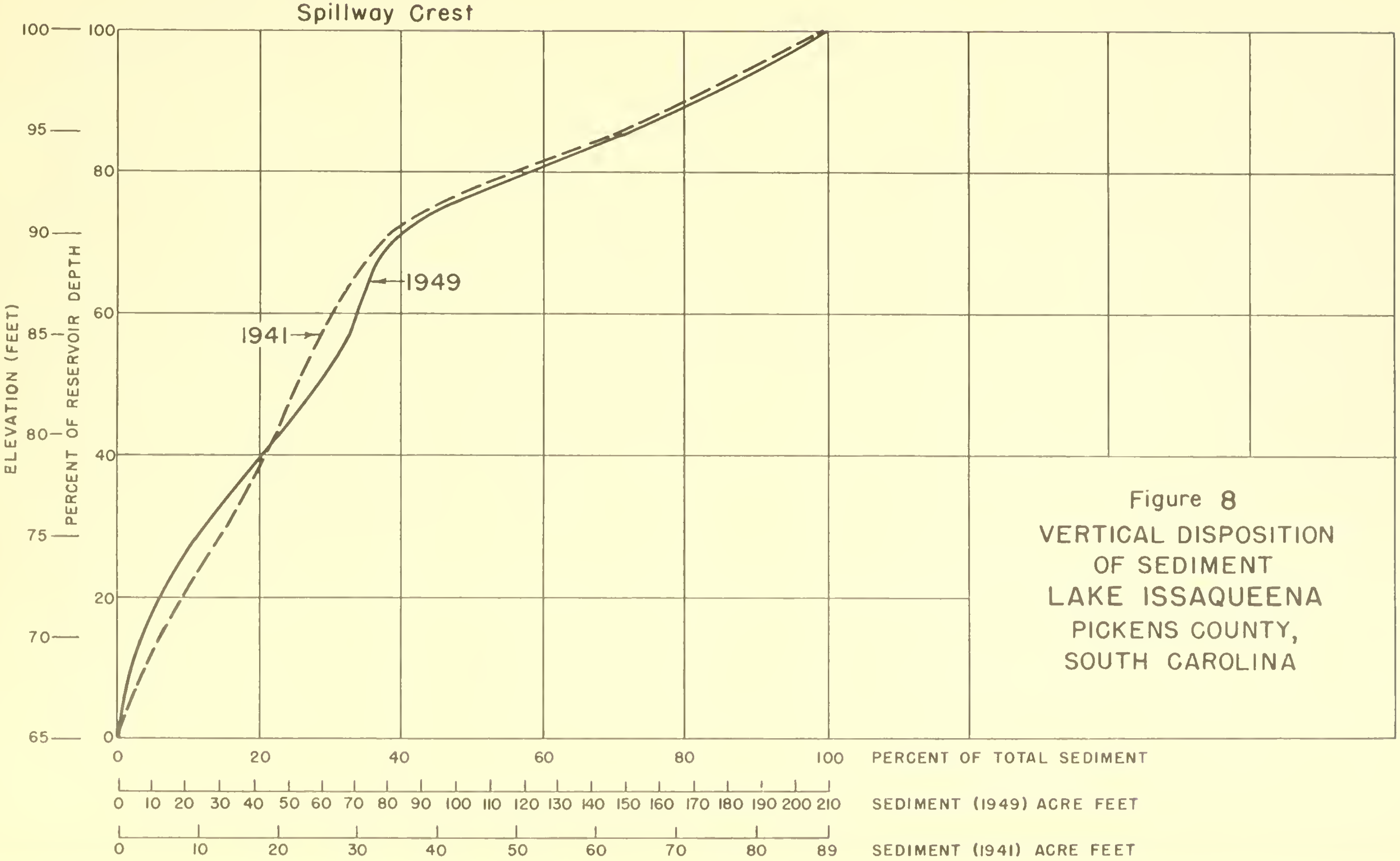

Figure 8
VERTICAL DISPOSITION
OF SEDIMENT
LAKE ISSAQUEENA
PICKENS COUNTY,
SOUTH CAROLINA

percent of reservoir depth, as well as actual volume in acre-feet, against elevation in feet. Approximately 60 percent of the sediment is deposited in the top 30 percent of the reservoir depth. This top 30 percent of the reservoir depth contains 55 percent of the lake capacity. Differences in the relative distribution of the lower-lying 40 percent of the sediment can be noted for the two survey dates, but the distribution of material within the lake at the time of the two surveys is not greatly different. Horizontal distribution of the sediment is shown in figure 9.

A summary of pertinent data concerning sedimentation in Lake Issaqueena is tabulated in table 4.

* * * * * * * * * * *

Table 4 - Summary of sedimentation data on Lake Issaqueena

	QUANTITY	UNIT
AGE[1]		
April 1941	2.9	Years
October 1949	11.4	Years
WATERSHED AREA (including area of lake)	14.02	Square miles.
	8,974	Acres
WATERSHED AREA (excluding area of lake)		
April 1941	13.84	Square miles
	8,857	Acres
October 1949	13.86	Square miles
	8,868	Acres
RESERVOIR:		
Area at spillway stage :		
Original	117	Acres
April 1941	114	Acres
October 1949	106	Acres
Storage capacity at crest level :		
Original	1,836	Acre-feet
April 1941	1,748	Acre-feet
October 1949	1,626	Acre-feet
Capacity per square mile of drainage area :[2]		
Original	131	Acre-feet
April 1941	125	Acre-feet
October 1949	116	Acre-feet
SEDIMENTATION:		
April 1941 survey :		
Total sediment	88.9[3]	Acre-feet
Bottom-set deposits	46.3	Acre-feet
Delta deposits	42.6	Acre-feet
October 1949 survey :		
Total sediment	210.6	Acre-feet
Bottom-set deposits	115.8	Acre-feet
Delta deposits	94.8	Acre-feet
SEDIMENTATION: (Continued)		
Average annual-accumulation :		
April 1941 survey:		
From entire drainage area	30.7[3]	Acre-feet
Per square mile of drainage area[4]	2.22[3]	Acre-feet
Per acre of drainage area:[4]		
By volume	151[3]	Cubic feet
By weight[5]	3.76[3]	tons
October 1949 survey:		
From entire drainage area	18.5	Acre-feet
Per square mile of drainage area[4]	1.33	Acre-feet
Per acre of drainage area:[4]		
By volume	90.9	Cubic feet
By weight[6]	2.31	Tons
Between surveys:		
From entire drainage area	14.3	Acre-feet
Per square mile of drainage area[4]	1.03	Acre-feet
Per acre of drainage area:[4]		
By volume	70.1	Cubic-feet
By weight	1.80	Tons
DEPLETION OF STORAGE:		
Loss of original capacity:		
Per year:		
1941 survey	1.67[3]	Percent
1949 survey	1.01	Percent
To date of survey:		
1941 survey	4.84[3]	Percent
1949 survey	11.5	Percent

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[1] *Storage began June 1938; average date of first survey April 15, 1941; average date of resurvey October 5, 1949*

[2] *Including area of lake.*

[3] *Discrepancy from original (1941) figures caused by recalculation.*

[4] *Excluding area of Lake.*

[5] *Average specific weight of 49.82 pounds per cubic foot determined from 20 undisturbed samples.*

[6] *Based on dry weights determined from 14 undisturbed samples secured in 1949 and 12 undisturbed samples secured in 1941. specific weights for the different samples are as follows: Segments 0,1,2,3,4,5,6,7,8,9,17,and 18 at 35 pounds; Segment 10 at 38 pounds; Segment 11 at 39 pounds; Segments 12, 13, 14, and 19 at 52 pounds; and Segments 15,16, and 20 at 72 pounds. Average: 50.9 pounds per cubic foot.*

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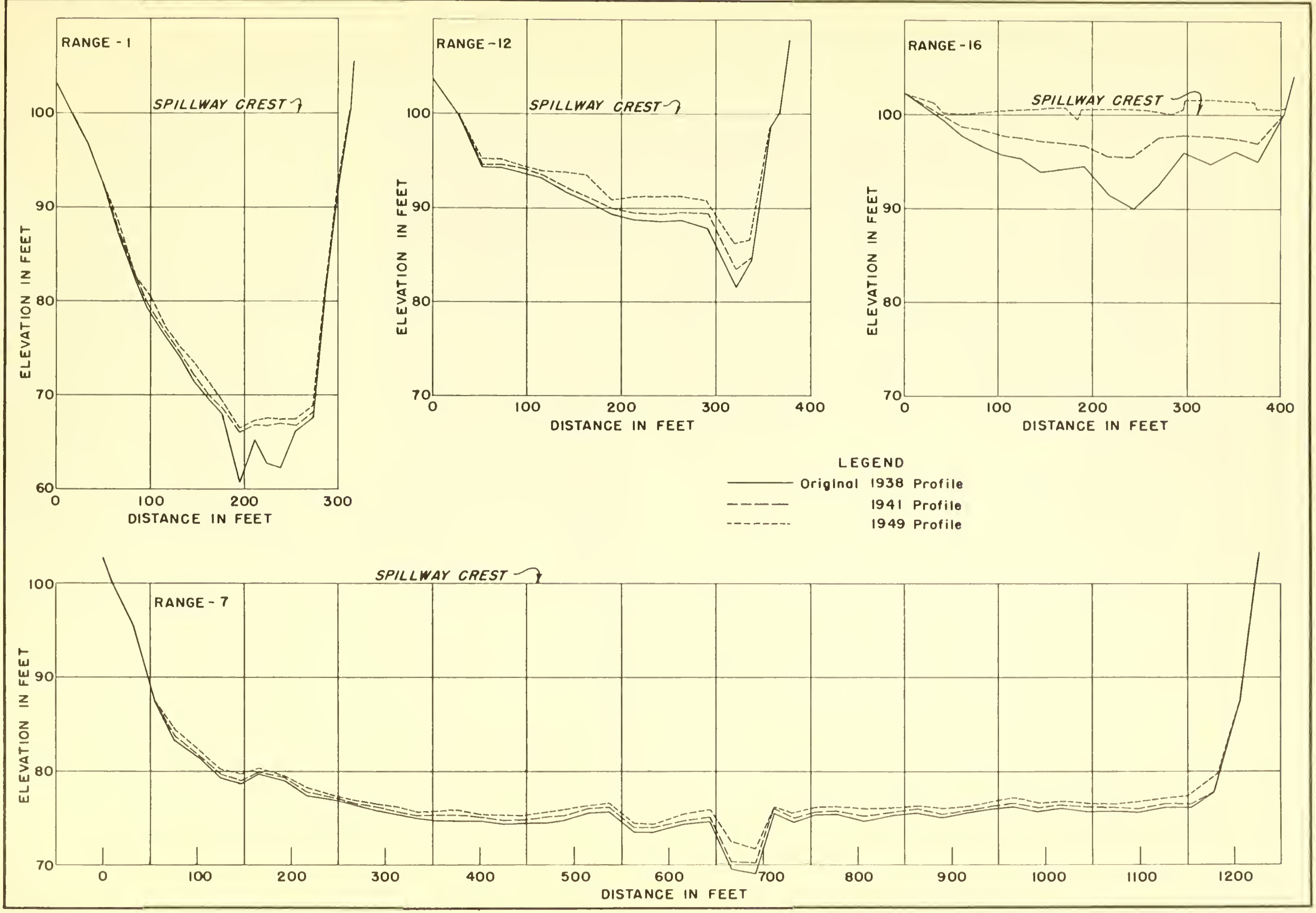

FIG-9 REPRESENTATIVE RANGE PROFILES - LAKE ISSAQUEENA - PICKENS COUNTY - SOUTH CAROLINA

Road-bank Erosion

A resurvey of the road banks in 1949 showed that 56,000 feet, or 32 percent of the 176,000 linear feet of road banks eroding in 1941, had become stabilized. An additional 4,600 feet of road banks not eroding in 1941, were eroding in 1949. The net decrease in the amount of road-bank erosion was 31 percent. Almost all of the improvement in the condition of the road banks was from natural stabilization (fig.10). About 2,000 feet of road banks were sloped and planted at about the time of the first survey, and those planted banks now have a dense protective vegetative growth (fig.11). Many of the secondary roads, particularly in the lower watershed, have been abandoned since the first survey. Most of these old roadways are gradually becoming stabilized by volunteer weed growth.

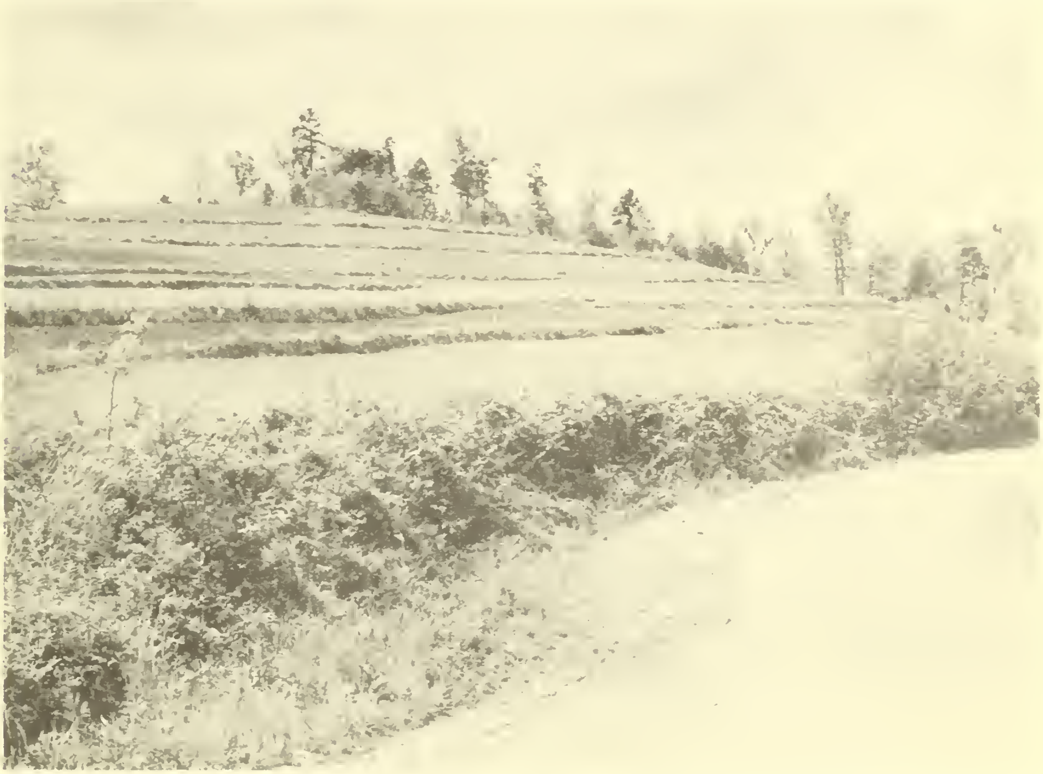

Figure 10 - Road bank stabilized by natural revegetation (1950).

Streambank Erosion

A resurvey of the stream banks in 1949 indicated that the condition of the streambanks was about the same as in 1941. There had been a small reduction in the amount of streambank erosion in the lower watershed; most of it a result of natural stabilization. A small amount of streambank stabilization work was done in connection with the Land Utilization Project (figs.12 and 13).

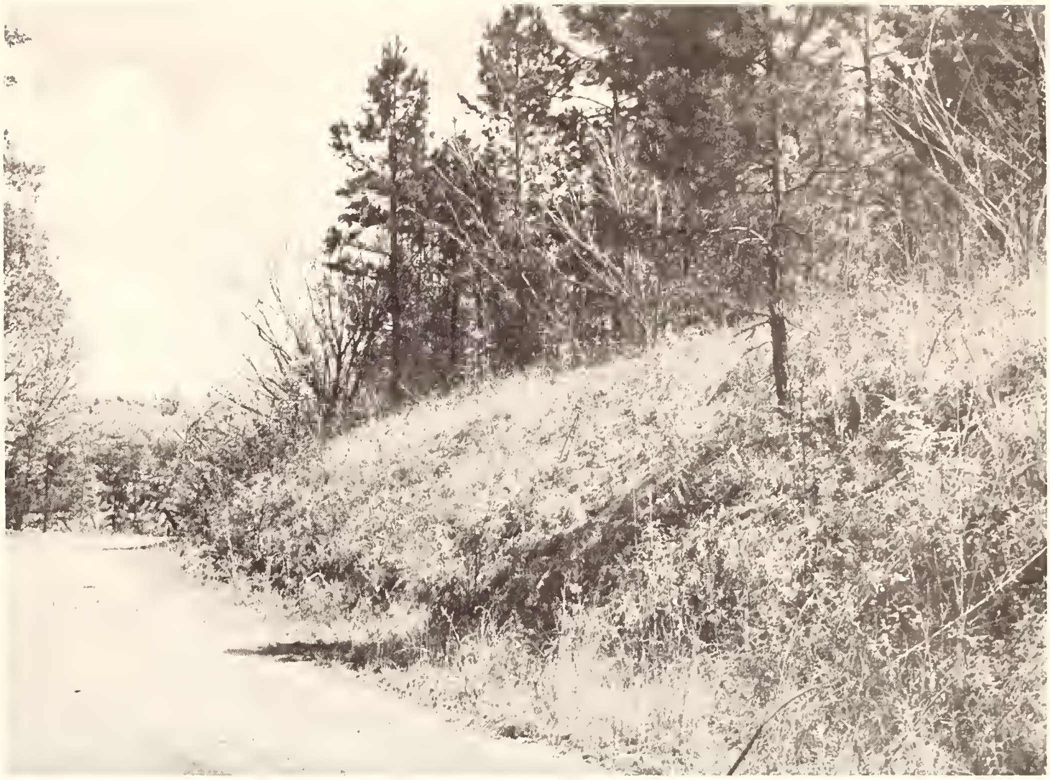

Figure 11 - Road bank (1950) approximately ten years after sloping and planting for stabilization.

Gully Erosion

Most of the deep, caving-type gullies shown in the 1941 conservation survey were partially or completely stabilized in 1949. The largest gully in the watershed, located near Six Mile School No. 1, has been almost completely stabilized by kudzu. Many of the smaller gullies have been obliterated by new terraces and contour cultivation. Erosion has been considerably reduced by natural healing on many of the badly galled and gullied abandoned lands. One large gully has, however, developed recently below the turn-out from a new road ditch (fig.14).

Sheet Erosion

Available data indicate that sheet erosion is the major source of sediment. The principal factors influencing sheet erosion are precipitation, soil characteristics, slope, and land use. Rainfall and resulting runoff were greater during the second period (1941-49) than during the first period (1938-41). Soils and slopes remained unchanged. With an increase in rainfall and no change in the second and third factors during the second period, the change in land use and treatment appears to be the only important factor that could have caused reduced sediment production.

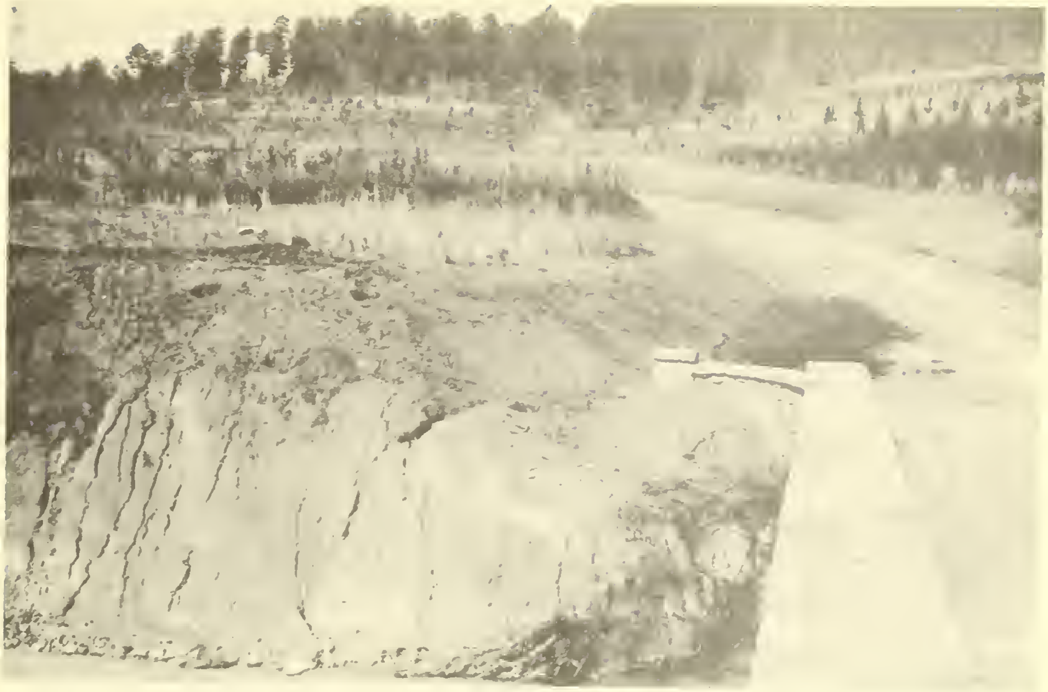

Figure 12 - Streambank prepared for planting to kudzu, 1940. Note planted pines in background.

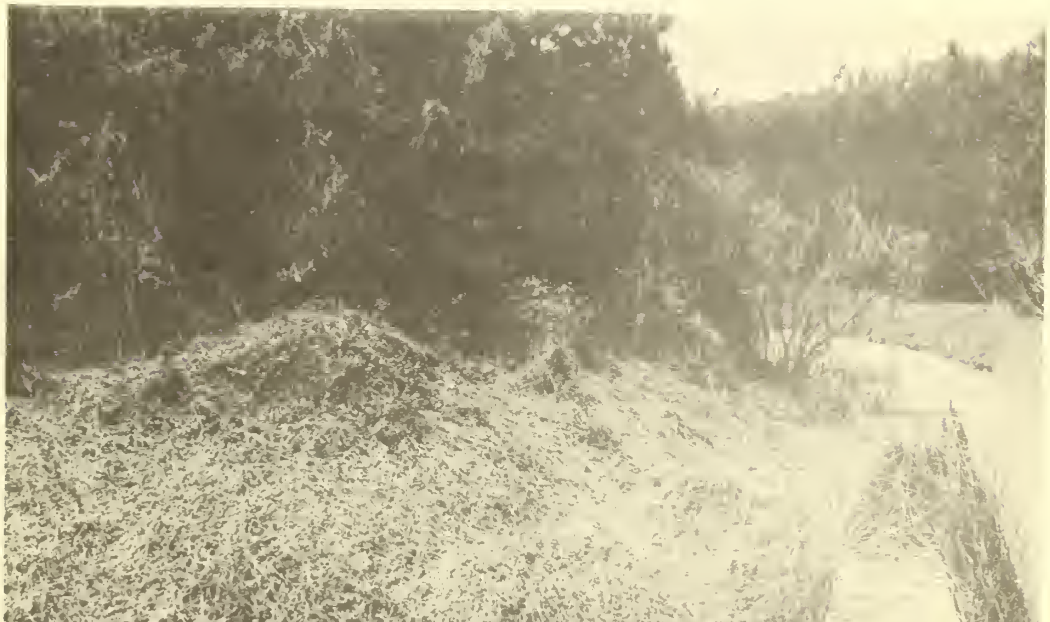

Figure 13 - Same streambank and pine plantation in 1950.

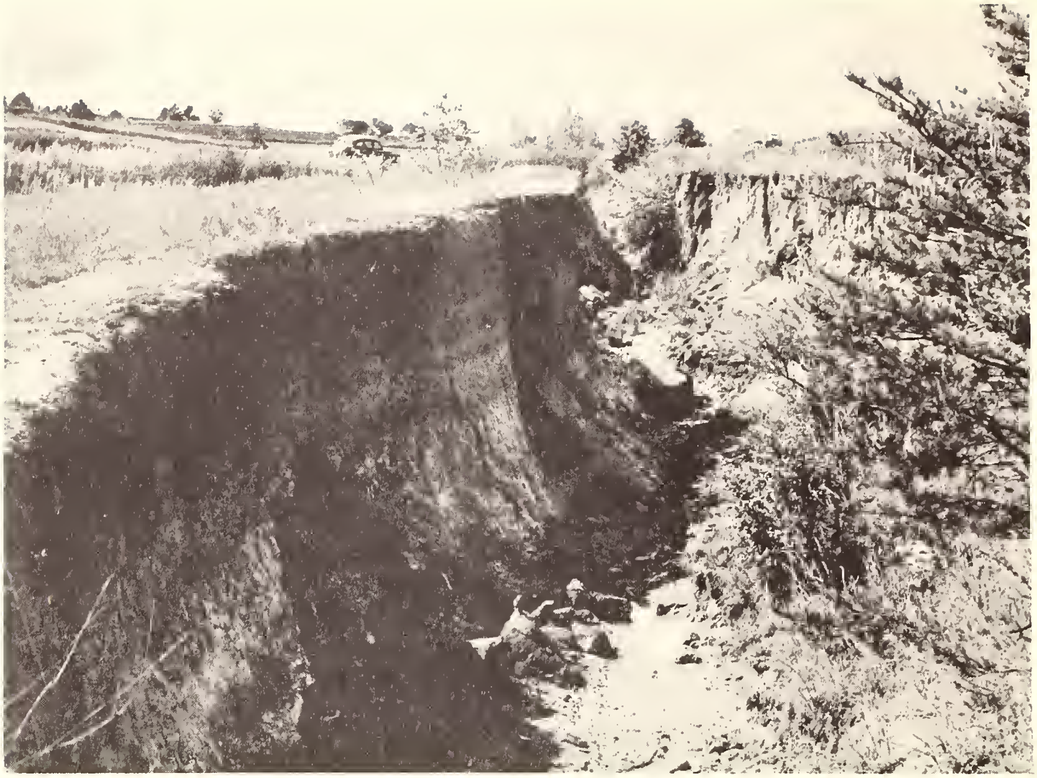

Figure 14 - Actively caving gully (1950) caused by turn-out water from road ditch. It was estimated that this gully produced 2,300 tons of sediment in 7 years.

Land-use Changes

In 1941, a detailed conservation survey showing soils, slope, erosion, and land use was made on the Lake Issaqueena Watershed. Late in 1949 a detailed land-use survey was made of the same area. Land use in 1949 was was mapped on the 1941 field sheets so that a direct comparison of changes in cover could be made. The land-use legend used on the 1949 survey is given below:

L_1 - Clean-cultivated crops (cotton and corn)
L_2 - Strip cropped (more than ½ close-growing crops)
L_3 - Annual close-growing crops (small grains and lespedeza)
L_4 - Perennial crops (kudzu and sericea)
P_1 - Pasture with good forage cover
P_2 - Pasture with poor forage cover
X_1 - Idle land with good vegetative cover
X_2 - Idle land with poor vegetative cover
FA - Woodland with medium to good cover
FB - Woodland with poor cover
H - Urban and miscellaneous

In order to determine the extent to which the land was in proper use and as a further clue to sediment sources, the lands in the watershed were classed according to use capability; a classification of

SOIL CONSERVATION SERVICE
H. H. Bennett, Chief

U. S. DEPARTMENT OF AGRICULTURE

SOUTHEASTERN REGION
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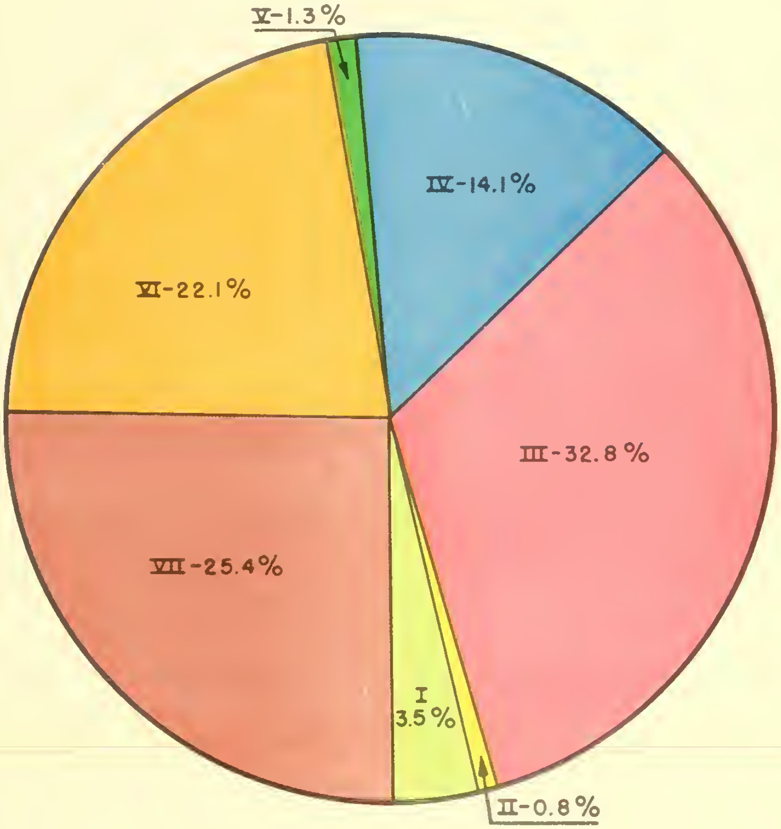
Figure-15

LAND CAPABILITY CLASSES

LAKE ISSAQUEENA WATERSHED

PICKENS COUNTY, SOUTH CAROLINA



MAJOR LAND USE SUITABILITY	LAND CAPABILITY CLASS	DEFINITION AND LIMITATIONS	GENERAL RECOMMENDATIONS	
			CULTIVATED (PERCENT)	COVER (PERCENT)
SUITED FOR CULTIVATION	I	Very good land. Bottom land suitable for continuous cultivation with few limitations.	100	
	II	Good land. Gently sloping ridge tops and second bottoms with slight to moderate erosion. Moderate limitations.	50	50
	III	Moderately good land. Sloping uplands with moderate to severe erosion. Regular cultivation possible with soil building practices, terracing and contour strip cropping.	$33\frac{1}{3}$	$66\frac{2}{3}$
	IV	Fairly good land. Suitable for occasional cultivation with severe limitations.	25	75
NOT SUITED FOR CULTIVATION	V	Wet, sandy bottom lands subject to frequent overflow. Best suited to water-loving hardwoods.		100
	VI	Steep lands requiring continuous vegetation. Suited for trees, or for pasture if carefully managed.		100
	VII	Very steep, stony or gullied land suited for trees or grass with very careful management.		100

Table 5 - Land use shown by land capability classes, 1941 and 1949.

LAND USE	LAND CAPABILITY CLASS														MISCELLANEOUS		TOTAL	
	UPLAND										BOTTOM LAND							
	II		III		IV		VI		VII		I		V					
	1941	1949	1941	1949	1941	1949	1941	1949	1941	1949	1941	1949	1941	1949	1941	1949	1941	1949
	ACRES	ACRES	ACRES	ACRES	ACRES	ACRES	ACRES	ACRES	ACRES	ACRES	ACRES	ACRES	ACRES	ACRES	ACRES	ACRES	ACRES	ACRES
CROPLAND																		
Clean cultivated[1]	25	15	1,949	965	560	395	217	99	359	198	192	103	16	7			3,318	1,782
Strip cropped[2]	0	11	0	1,039	0	62	0	137	0	143	0	20	0	0			0	1,412
Close-growing annuals[3]	8	7	649	265	186	67	65	11	119	35	0	3	0	0			1,027	388
Close-growing perennials[4]			0	14	0	28			0	28	0	18	0	0			0	88
Total	33	33	2,598	2,283	746	552	282	247	478	404	192	144	16	7			4,345	3,670
PASTURE																		
With good cover	0	4	43	79	39	80	7	17	114	82	12	23	32	17			247	302
With poor cover	2	2	30	19	73	67	25	40	100	133	0	18	0	15			230	294
Total	2	6	73	98	112	147	32	57	214	215	12	41	32	32			447	596
IDLE LAND																		
With good cover	18	0	33	212	58	163	17	45	82	97	12	26	28	70			248	613
With poor cover	0	0	20	64	26	36	2	7	102	33	0	0	0	0			150	140
Total	18	0	53	276	84	199	19	52	184	130	12	26	28	70			398	753
WOODLAND																		
With good cover	12	28	137	211	244	324	1,546	1,592	1,111	1,357	95	96	24	2			3,169	3,610
With poor cover	2	0	29	22	56	20	69	0	254	135	0	4	0	0			410	181
Total	14	28	166	233	300	344	1,615	1,592	1,365	1,492	95	100	24	2			3,579	3,791
MISCELLANEOUS																		
Housesites, urban areas															58	58	58	58
Lake area															117	106	117	106
Total																	175	164
GRAND TOTAL	67	67	2,890	2,890	1,242	1,242	1,948	1,948	2,241	2,241	311	311	100	111	175	164	8,974	8,974
NET SEDIMENT CONTRIBUTING AREA																	8,857	8,868[5]

---

[1] Cotton, corn, etc.

[2] More than ½ in close-growing crops. Rotation strip-cropping not in use in 1941.

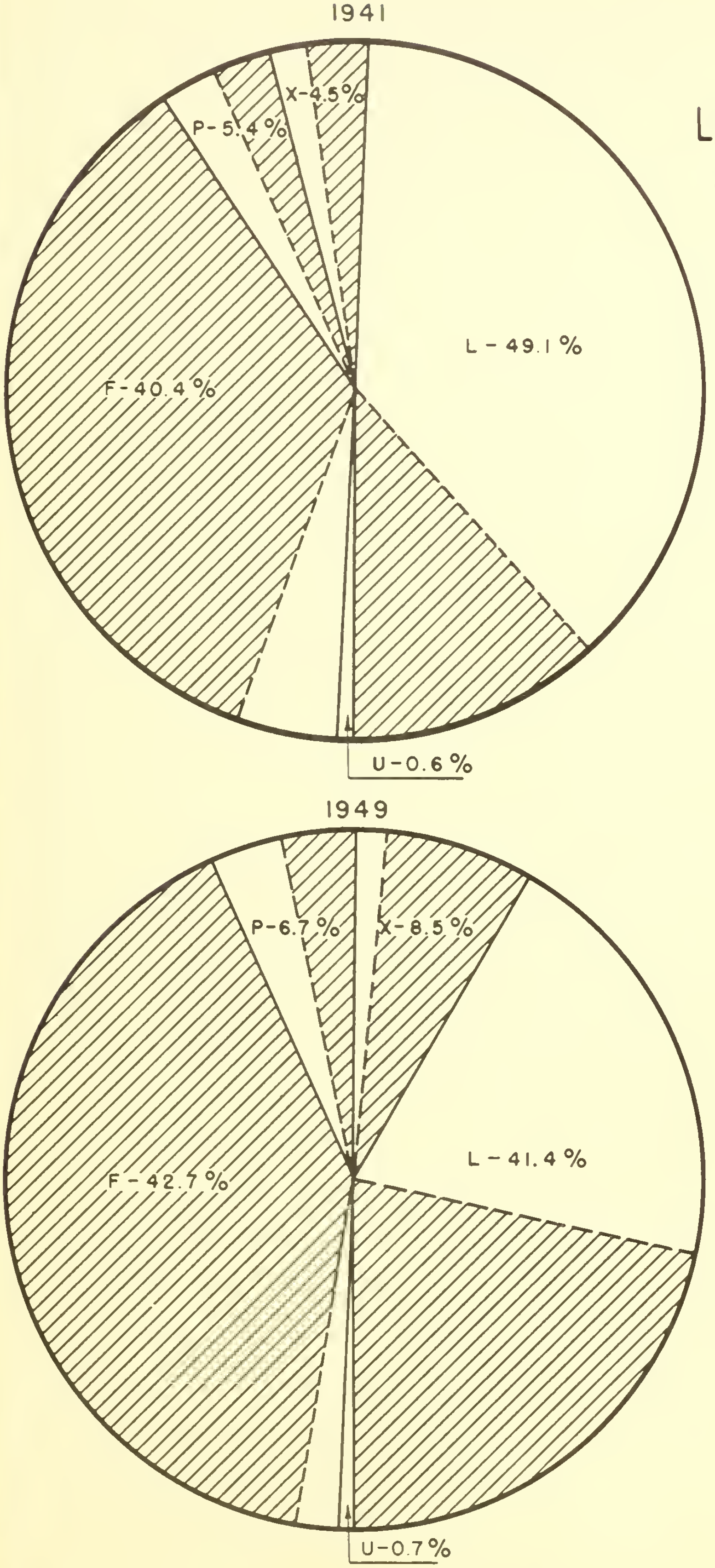
[3] Small grain and lespedeza.

[4] Kudzu and sericea. Perennial hay not in use in 1941.

[5] Increase in contributing area due to 11 acre increase in above-crest delta deposits.

Figure 16

DISTRIBUTION OF LAND USE
LAKE ISSAQUEENA WATERSHED
PICKENS COUNTY, SOUTH CAROLINA



LEGEND

L - Cultivated Land
X - Idle Land
P - Pasture Land
F - Woodland
U - Urban and Miscellaneous

▨ Land With Moderate To Good Erosion Protection

☐ Land With Poor Erosion Protection

different kinds of land according to those properties that determine the ability of the land to produce permanently with a minimum of soil loss. The distribution of land-capability classes in the watershed and a brief definition of each class is shown in figure 15. The distribution of land use at the time of each survey is shown by land-capability classes in table 5.

The land use mapped in the 1941 survey was much less detailed than in the 1949 survey. Therefore, the 1941 survey data were supplemented by census data and information from farmers and professional agricultural workers in order to make a better comparison of land use for the two periods.

Figure 16 shows land use in the watershed for the two periods and the estimated condition of each from the standpoint of protection from erosion. In 1941 about 53 percent of the watershed had moderate to good erosion protection, and 47 percent had poor protection. In 1949, approximately 73 percent of the area was classed as having moderate to good erosion protection, and 27 percent with poor protection.

The biggest improvement has been on cultivated lands where the proportion of area with moderate to good erosion protection has doubled. The condition of the woodland in 1941 was estimated at 88 percent medium to good cover and 12 percent poor cover. In 1949,95 percent of the woodland was in medium to good condition and 5 percent in poor condition. Much of the woodland improvement was due to the greater protection afforded by increased growth in the pine plantings (fig. 17). Most of these plantings, totaling 558 scres, are in the Clemson Land Utilization Project on steep, critical areas which formerly produced large amounts of sediment. Better fire protection also has had much to do with improved woodland conditions.

During the period 1941 to 1949, the amount of cropland was reduced 15.5 percent while amounts of pasture, idle land, and woodland were increased. Most of the reduction in cultivated area occurred in the Clemson Land Utilization Project where fields, formerly cultivated, had reverted to broom sedge and other native vegetation which, for the most part, furnishes moderate to good erosion protection (figs.18 and 19). This change is of considerable significance since these fields are steep and eroded, and the sediment that originates on them has a relatively short distance to travel before being deposited in the reservoir.

Conservation Practices

Lake Issaqueena Watershed is a part of the Upper Savannah Soil Conservation District. About 40 percent of the privately-owned farm lands are operated under complete soil and water conservation plans in cooperation with the Upper Savannah District.

The differences in soil loss from clean-cultivated and strip-cropped fields indicate that the 1,412 acres of rotation strip cropping (fig.20) put into effect on the watershed since the previous survey has been an important contributing factor to the reduced rate of sedimentation.

Another factor contributing to sediment reduction was the increased acreages in pasture and perennials.

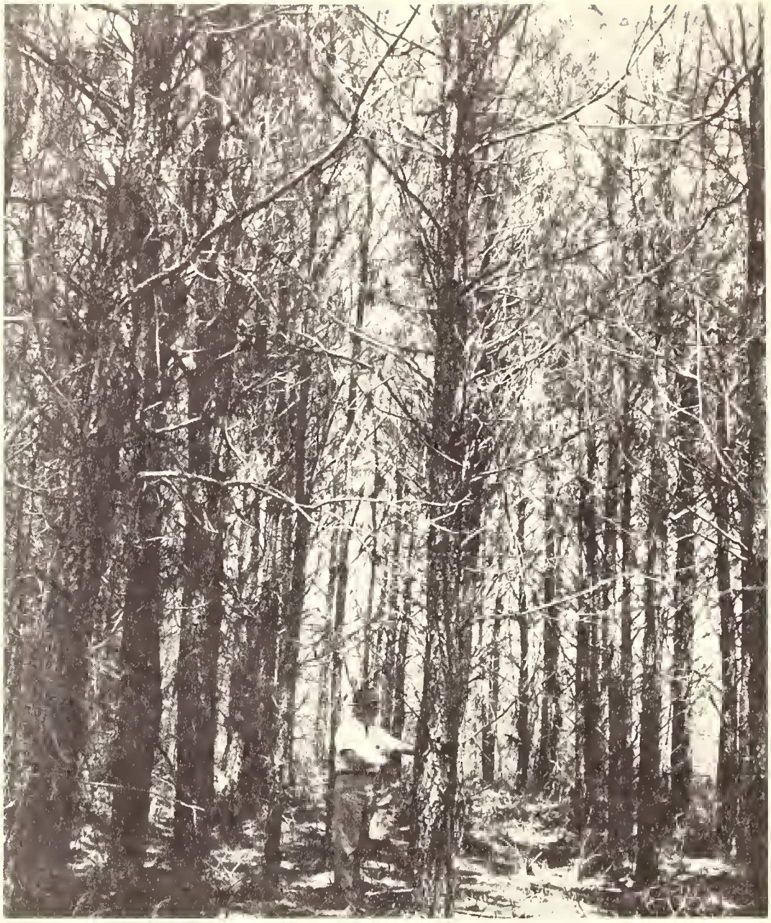


Figure 17 - Pines planted in 1938. Control of erosion is complete after twelve years of growth

Terracing has been a general practice in the watershed for the past 50 years or more. However, the old terraces were generally narrow-based, very often improperly laid out and had poor outlets. These terraces very often became benched (fig.21). The modern terraces now in general use in the watershed are much more effective in reducing soil loss. Broad-base, channel-type terraces are now recommended on land with up to 8 percent slope. Above 8 percent, a modified broad-base terrace is used. Areas having more than 15 percent slope are recommended only for woodland, pasture or perennial hay. Natural outlets are utilized to a much greater extent than formerly.

There has been some pasture improvement work in the watershed during the last few years, along with an increase in pasture acreage.

The changes in land use and conservation practices put into effect on the watershed between 1941 and 1949, while affecting only 20 percent of the total watershed area, were largely responsible for the reduced rates of sedimentation. The explanation lies in the fact that most of these improvements were on the badly eroding lands which were producing most of the sediment.

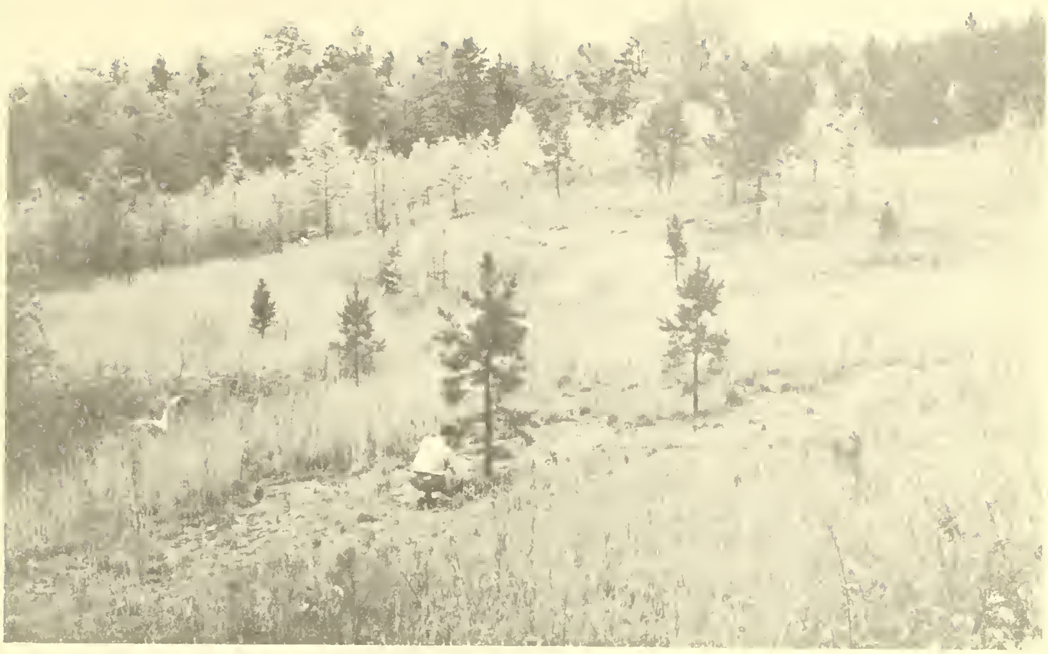


Figure 18 - An area of idle land with poor cover (X-2 land-use designation)

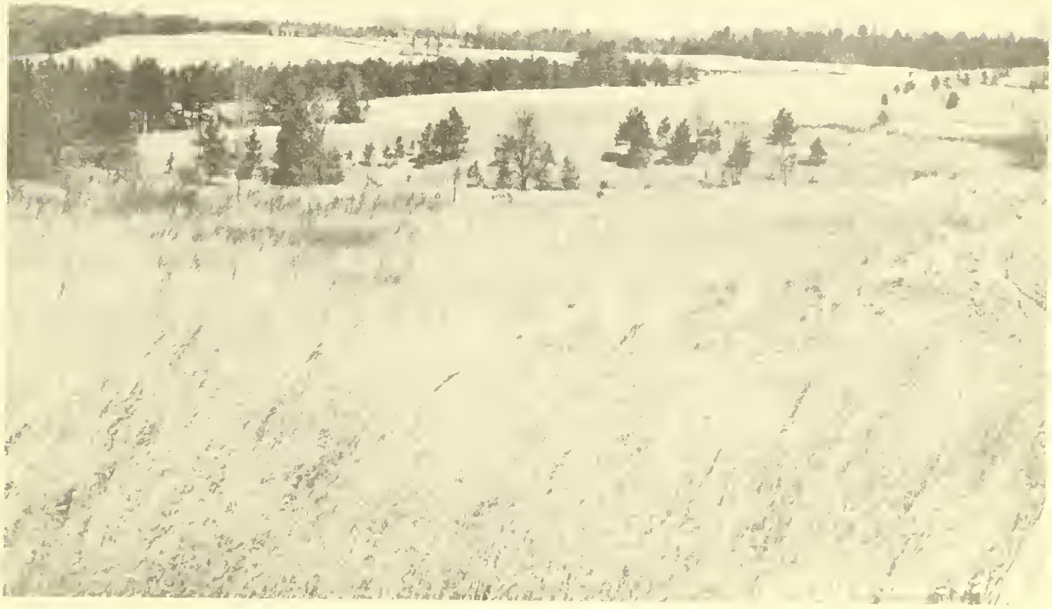


Figure 19 - An area of idle land with good cover (X-1 land-use designation)

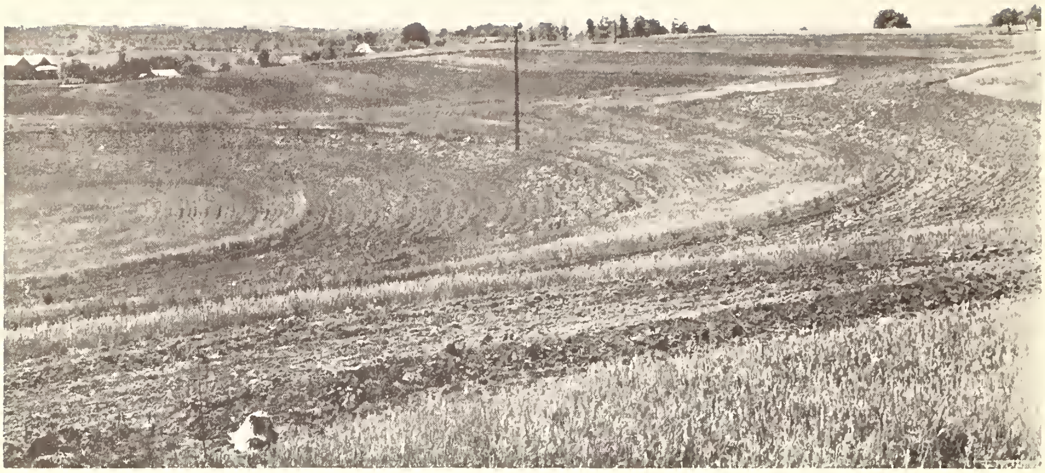


Figure 20 - Terraced and strip-cropped field. A good example of erosion protection on Land-capability Class III land.

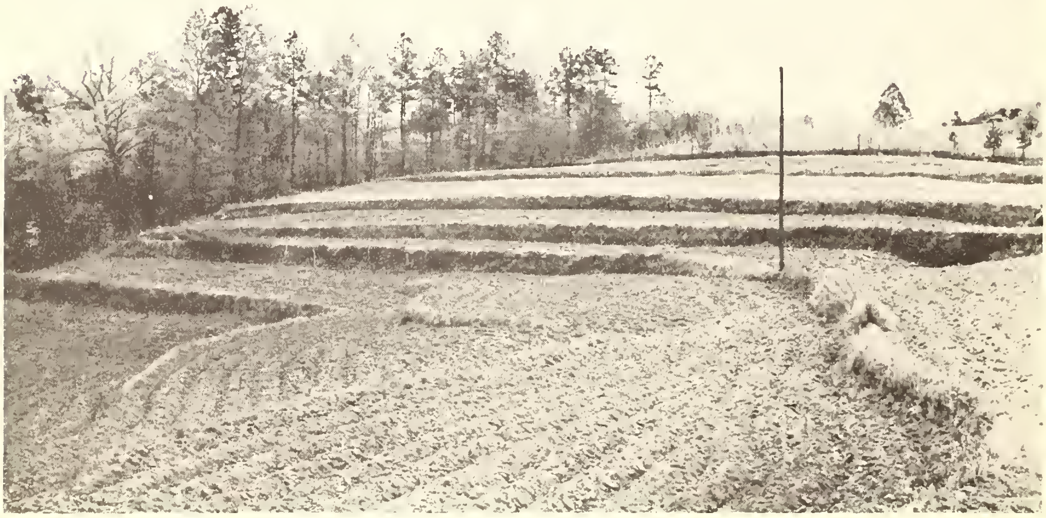


Figure 21 - Bench terraces on Land-capability Class IV and VII land.

Comparison of Sedimentation Rates with Erosion Losses

The amount of sediment deposited in Lake Issaqueena represents only a portion of the total amount of soil material eroded. Data from the Southern Piedmont Conservation Experiment Station at Watkinsville, Georgia[1,2], and estimates based on other research were used to estimate the rates of soil erosion.

Estimates were made of the average annual soil loss from field-size areas, expressed in tons per acre, for each kind of land use in the different land-capability classes, table 6. The acres in each catagory, table 5, were multiplied by the tons of soil lost annually in that catagory. The total of these weighted figures was the estimated average annual soil loss, or total soil movement due to sheet erosion.

The experimental plot measurements, from which the annual soil loss figures were largely derived, reflect only sheet and rill erosion. It is believed, however, that these annual soil loss figures represent,by far, the greater part of the gross soil loss.

It is estimated that the average annual soil movement from sheet erosion under 1941 conditions was 107,465 tons. Improved land-use conditions and conservation practices had reduced this estimated average annual loss to 68,154 tons by 1949, a reduction in soil movement of 36.6 percent. These totals, on a per-acre basis, are 12.1 and 7.69 tons per acre per year, respectively. For the corresponding periods the annual amounts of material deposited in the lake were 3.6 tons per acre and 1.80 tons per acre, a reduction of about 52 percent. Reduction in the the amount of sheet erosion is considered to be responsible for a large part of the reduction in the reservoir sedimentation rate although there have also been reductions in other sources of sediment such as major gullies and roads.

A comparison of the amounts of total soil movement from sheet erosion with amounts of sediment deposited in the lake shows that a smaller portion of eroded material is getting into the lake than formerly. In 1941, sediment deposits represented 31 percent of the annual soil loss by sheet erosion. In 1949, this figure was 23.4 percent. The formation of natural desilting areas of dense vegetative growth on the abandoned bottom lands above the reservoir and the reduced stream gradients in this area are believed to be responsible for much of the reduced ratio of sedimentation to soil loss.

Sedimentation in the lake accounts for only a part of the total soil movement. Most of the soil not accounted for moves only part way down the slopes and remains in the watershed as colluvial or alluvial deposits. A small portion, estimated at about 8 percent of the total material entering the lake, stays in suspension and is carried over the dam.

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[1] *Review of Principal Results,1947,Southern Piedmont Conservation Experiment Station,Watkinsville,Georgia,May 1948.*

[2] *1948 Progress Report and Review of Results, Southern Piedmont Conservation Experiment Station,Watkinsville,Georgia,March 1949.*

Table 6 - Average annual per acre soil loss

LAND USE	LAND-CAPABILITY CLASS						
	UPLAND					BOTTOM LAND	
	II	III	IV	VI	VII	I	V
	Tons	*Tons*	*Tons*	*Tons*	*Tons*		
Cropland - clean cultivated	5	21	22	42	66	--	--
Cropland - strip crop	2	3	7	13	22	--	--
Cropland - small grain and lespedeza	1	2	5	10	15	--	--
Cropland - perennial hay	0.1[1]	0.1	0.1	0.1	0.1	--	--
Pasture - good cover	0.1	0.1	0.1	0.1	0.1	--	--
Pasture - poor cover	1	2	6	10	16	--	--
Idle Land - good cover	0.1	1	2	5	8	--	--
Idle Land - poor cover	5	21	22	42	66	--	--
Woodland - good cover	0.1	0.1	0.1	0.1	0.1	--	--
Woodland - poor cover	1	5	6	10	16	--	--

[1] *Soil loss less than 0.5 tons per acre per year, ranging from 0.03 for good woodland to 0.32 for newly established sericea.*

Needed Improvements

Although the average rate of sediment production has been reduced from 2.22 to 1.03 acre-feet per square mile per year, a reduction of 53.6 percent, it is still about double the average rate for the Piedmont area. Land-use conditions are far from ideal.

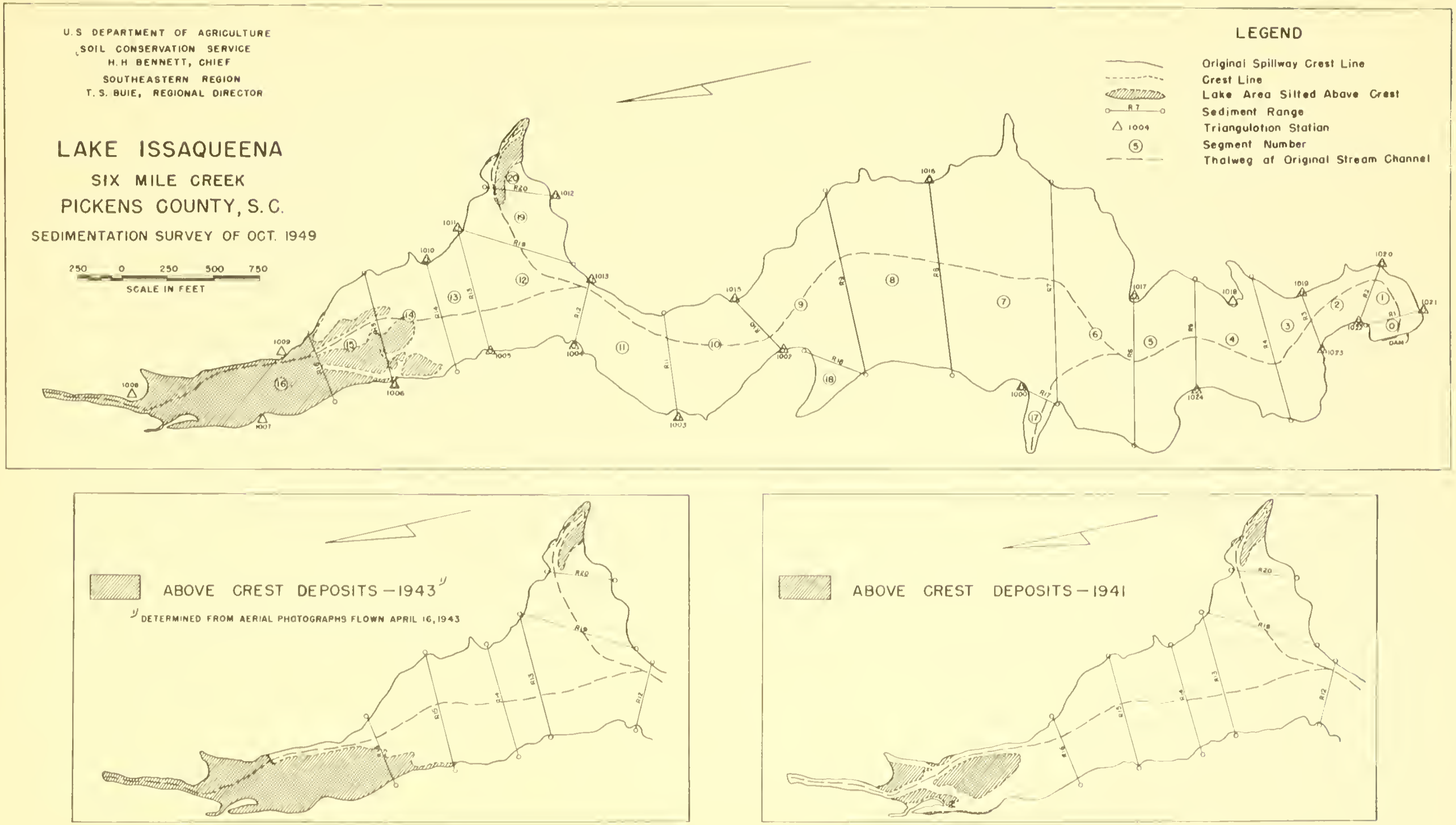
The same calculation used to determine average annual soil movement for 1941 and 1949 was used to determine the rate of soil loss with all watershed lands treated and in proper use. This calculation showed, theoretically at least, that with ideal watershed conditions the annual rate of soil movement would be .95 tons per acre, a reduction of 92 percent from the rate in 1941. Assuming that 23.4 percent of the total erosion material produced would be deposited in the lake (the same ratio as that for 1949) the annual rate of sedimentation in the lake would be reduced by 94 percent.

While it may be impractical, or impossible, to obtain ideal land-use conditions this calculation shows that a complete conservation program would be extremely effective in reducing reservoir sedimentation.

The greatest need for improvement is on the cultivated areas. Even with the many improved practices put into effect during recent years almost half of the cultivated land, representing 20 percent of the watershed, is still classed as having poor erosion protection. Probably the greatest single remaining source of sediment is the 651 acres still under cultivation on land-capability classes VI and VII. These areas are highly susceptible to erosion and should be converted to permanent vegetation.

* * * * * * * * *

Figure 22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SOUTHEASTERN REGION
T. S. BUIE, REGIONAL DIRECTOR
LAKE ISSAQUEENA
SIX MILE CREEK
PICKENS COUNTY, S. C.
SEDIMENTATION SURVEY OF OCT. 1949
250 0 250 500 750
SCALE IN FEET
LEGEND
Original Spillway Crest Line
Crest Line
Lake Area Silted Above Crest
R 7
Sediment Range
1004
Triangulation Station
5
Segment Number
Thalweg of Original Stream Channel
DAM
1000
1003
1004
1005
1006
1007
1008
1009
1010
1011
1012
1013
1015
1016
1017
1018
1019
1020
1021
1023
1024
R1
R2
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R4
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R6
R7
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R9
R10
R11
R12
R13
R14
R15
R16
R17
R18
R19
R20
ABOVE CREST DEPOSITS – 1943 1/
1/ DETERMINED FROM AERIAL PHOTOGRAPHS FLOWN APRIL 16, 1943
ABOVE CREST DEPOSITS – 1941